Electricity

Electricity consumption nearly doubles in the IEO2002 projections. Developing nations in Asia and in Central and South America are expected to lead the increase in world electricity use.

In the *International Energy Outlook 2002* (*IEO2002*) reference case, worldwide electricity consumption is projected to increase at an average annual rate of 2.7 percent from 1999 to 2020 (Table 20 and Figure 74). The most rapid growth in electricity use is projected for the developing world, particularly developing Asia, where electricity consumption is expected to increase by 4.5 percent per year over the forecast horizon. Robust economic growth in developing Asia is expected to lead to increased demand for electricity to run newly purchased home appliances, such as air conditioners, refrigerators, stoves, space heaters, and water heaters. By 2020, developing Asia is expected to consume more than twice as much electricity as it did in 1999. China's electricity consumption alone is projected to triple, growing by an average of 5.5 percent per year over the forecast period.

Similarly, in Central and South America, high rates of economic growth are expected to improve standards of living and increase the demand for electricity for homes, businesses, and industry. The expected growth rate for electricity use in Central and South America is 3.9 percent per year between 1999 and 2020. For Brazil, the region's largest economy and largest consumer of electricity, electricity use is projected to increase by 3.6 percent per year, with increasing efforts to bring electrification to rural populations that have previously not had access to the national grid.

Electricity consumption in the industrialized world is expected to grow at a more modest pace than in the developing world, at 1.9 percent per year—a considerably lower rate than has been seen in the past. In addition to expected slower growth in population and economic activity in the industrialized nations, market saturation and efficiency gains for some electronic appliances are expected to slow the growth of electricity consumption.

There have been two important developments in the electricity sector in recent years that may affect the way the industry works in the future. The first is the increasing role of foreign direct investment in the developing regions of the world. Greater access to foreign investment in the electricity sector has allowed developing nations to construct the infrastructure needed for substantial increases in access to electricity, a particular problem for many developing nations.

A second important component of the electric industry's evolution over the past several years is electricity reform. Many developing countries have implemented reforms to the rules governing electricity generation and

Table 20. World Net Electricity Consumption by Region, 1990-2020
(Billion Kilowatthours)

Region	History		Projections				Average Annual Percent Change, 1999-2020
	1990	1999	2005	2010	2015	2020	
Industrialized Countries	**6,385**	**7,517**	**8,620**	**9,446**	**10,281**	**11,151**	**1.9**
United States	2,817	3,236	3,793	4,170	4,556	4,916	2.0
EE/FSU	**1,906**	**1,452**	**1,651**	**1,807**	**2,006**	**2,173**	**1.9**
Developing Countries	**2,258**	**3,863**	**4,912**	**6,127**	**7,548**	**9,082**	**4.2**
Developing Asia	1,259	2,319	3,092	3,900	4,819	5,858	4.5
China	551	1,084	1,523	2,031	2,631	3,349	5.5
India	257	424	537	649	784	923	3.8
South Korea	93	233	309	348	392	429	3.0
Other Developing Asia	357	578	724	872	1,012	1,157	3.4
Central and South America	449	684	788	988	1,249	1,517	3.9
Total World	**10,549**	**12,833**	**15,182**	**17,380**	**19,835**	**22,407**	**2.7**

Note: EE/FSU = Eastern Europe and the former Soviet Union.
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

distribution in an effort to secure the foreign direct investment they need to modernize and improve the electricity infrastructure. In industrialized countries, many nations have undertaken electricity reforms to introduce greater competition in domestic markets in an effort to reduce the costs of electricity to consumers. These two factors are driving changes within the electricity sector and are expected to have a profound role on the development of the industry over the next two decades.

Primary Fuel Use for Electricity Generation

The mix of primary fuels used to generate electricity has changed a great deal over the past three decades on a worldwide basis. Coal has remained the dominant fuel, although electricity generation from nuclear power increased rapidly from the 1970s through the mid-1980s, and natural-gas-fired generation has grown rapidly in the 1980s and 1990s (Figure 75). In contrast, in conjunction with the high world oil prices brought on by the oil price shocks resulting from the OPEC oil embargo of 1973-1974 and the Iranian Revolution of 1979, the use of oil for electricity generation has been slowing since the mid-1970s.

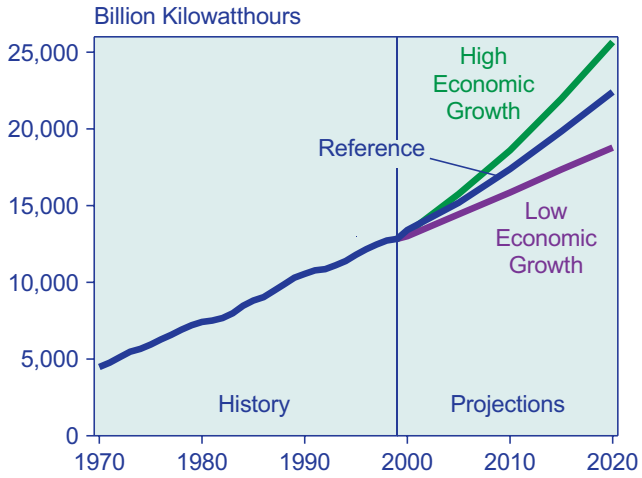
In the *IEO2002* reference case, continued increases in the use of natural gas for electricity generation are expected worldwide. Coal is projected to continue to retain the largest market share of electricity generation, but its importance is expected to be diminished somewhat by the rise in natural gas use. The role of nuclear power in the world's electricity markets is projected to lessen as reactors in industrialized nations reach the end of their lifespans and few new reactors are expected to replace them. Generation from hydropower and other renewable energy sources is projected to grow by more than 50 percent over the next 20 years, but their share of total electricity generation is projected to remain near the current level of 20 percent.

Natural Gas

Electricity markets of the future are expected to rely increasingly on natural-gas-fired generation. This trend is evident throughout the world, as industrialized nations are intent on using combined-cycle gas turbines, which generally are cheaper to construct and more efficient to operate than other fossil-fuel-fired generation technologies. Natural gas is also seen as a cleaner fuel than other fossil fuels. Worldwide, natural gas use for electricity generation is projected to double over the forecast period (Table 21), as technologies for gas-fired generation continue to improve and ample gas reserves are exploited. In the developing world, natural gas is expected to be used to diversify electricity fuel sources, particularly in regions like Central and South America, where heavy reliance on hydroelectric power has led to shortages and blackouts when reservoirs are low.

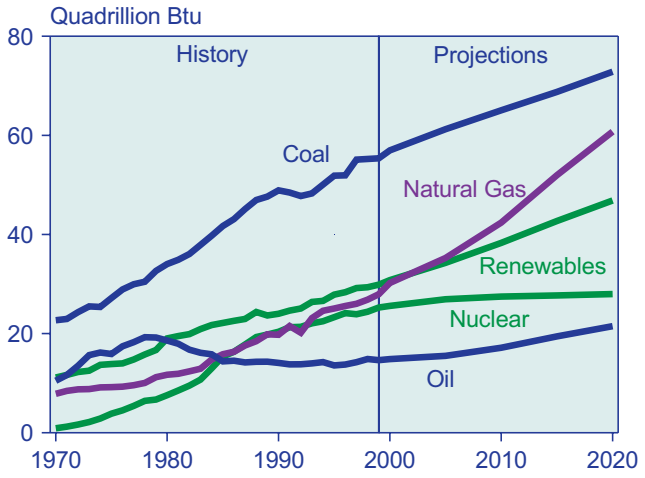
The former Soviet Union (FSU) accounted for more than one-third of natural gas use for electricity generation worldwide in 1999, and natural gas provided 51 percent of the energy used for electricity generation in the FSU. By 2020, natural gas is projected to account for 58 percent of the electricity generation market in the FSU. Relying increasingly on imports from Russia, the nations of Eastern Europe are also expected to increase

Figure 74. World Net Electricity Consumption in Three Cases, 1970-2020



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

Figure 75. World Energy Use for Electricity Generation, 1970-2020



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

their reliance on natural gas for electricity generation, from 10 percent in 1999 to 21 percent in 2020.

Natural gas use in the electricity generation sector is also expected to grow rapidly in North America and Western Europe. In the United States the natural gas share of the electricity fuel market is expected to double from 15 percent in 1999 to 32 percent in 2020, and in Canada the gas share is expected to grow from 3 percent in 1999 to 11 percent in 2020. The movement toward natural gas is expected to be accelerated by reduced reliance on nuclear power. In addition, Canadian exports are expected to provide a growing supply of natural gas to U.S. generators.

Western Europe is expected to see its use of natural gas double over the forecast period. In 1999 natural gas held a 14-percent share of the electricity fuel market in Western Europe. That share is projected to grow to 28 percent in 2020 as Western European nations reduce their reliance on nuclear power and coal. After the oil crisis of 1973, European nations (as in the United States) actively discouraged the use of natural gas for electricity generation and instead favored domestic coal and nuclear power over dependence on natural gas imports. In 1975 a European Union (EU) directive restricted the use of natural gas in new power plants. The natural gas share of the electricity market in Western Europe fell from 9 percent in 1977 to 5 percent in 1981, where it remained for most of the 1980s. In the early 1990s, the growing availability of reserves from the North Sea and increased imports from Russia and North Africa lessened concerns about gas supply in the region, and the EU directive was repealed. As a result, the natural gas share of electricity generation increased rapidly.

In Central and South America natural gas accounted for 11 percent of the electricity fuel market in 1999. Its share is projected to grow to 32 percent in 2020. Hydropower is the major source of electricity supply in South America at present, but environmental concerns, cost overruns on large hydropower projects in the past, and electricity shortfalls during periods of drought have prompted South American governments to view natural

Table 21. World Energy Consumption for Electricity Generation by Region and Fuel, 1995-2020
(Quadrillion Btu)

Region and Fuel	History		Projections			
	1995	1999	2005	2010	2015	2020
Industrialized	**77.1**	**83.8**	**91.4**	**97.5**	**104.4**	**110.5**
Oil	5.7	6.5	5.6	5.6	6.0	6.5
Natural Gas	9.7	11.6	15.6	18.1	22.8	26.6
Coal	27.7	29.6	32.3	34.1	35.0	35.9
Nuclear	19.4	20.6	21.1	21.1	20.8	20.3
Renewables	14.7	15.4	16.9	18.5	19.8	21.1
EE/FSU	**26.4**	**23.8**	**26.2**	**27.5**	**29.3**	**31.1**
Oil	2.8	2.4	3.2	3.7	4.4	4.9
Natural Gas	10.6	10.3	11.2	12.5	14.2	15.9
Coal	7.4	5.4	5.5	4.8	4.0	3.6
Nuclear	2.5	2.7	3.2	3.0	3.0	2.8
Renewables	3.1	3.0	3.2	3.4	3.7	4.1
Developing	**38.1**	**45.4**	**55.5**	**65.2**	**76.6**	**88.1**
Oil	5.1	5.7	6.8	7.9	9.0	10.2
Natural Gas	4.8	6.1	8.5	11.8	15.1	18.3
Coal	16.8	20.3	23.5	26.1	29.7	33.3
Nuclear	1.4	1.9	2.6	3.3	3.9	4.9
Renewables	10.1	11.5	14.1	16.1	18.9	21.4
Total World	**141.7**	**153.1**	**173.1**	**190.2**	**210.4**	**229.7**
Oil	13.6	14.6	15.5	17.1	19.4	21.5
Natural Gas	25.1	28.0	35.3	42.4	52.0	60.8
Coal	51.9	55.4	61.2	65.0	68.7	72.8
Nuclear	23.3	25.3	26.9	27.5	27.7	28.0
Renewables	27.9	29.9	34.1	38.1	42.5	46.6

Note: EE/FSU = Eastern Europe and the former Soviet Union.
Sources: **History:** Derived from Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, February 2001). **Projections:** EIA, World Energy Projection System (2002).

gas as a means of diversifying their electricity supplies. A continent-wide natural gas pipeline system is emerging in South America, which will transport Argentine and Bolivian gas to Chile and Brazil.

Per capita consumption of natural gas in Asia and Africa is relatively small when compared with Europe and North America. Japan alone accounts for 26 percent of natural gas consumption in Asia, and almost all the natural gas consumed in Japan is liquefied natural gas (LNG). Japan is expected to increase its dependence on natural gas from 21 percent of the electricity fuels market in 1999 to 23 percent in 2020.

Coal

In 2020, coal is expected to account for 32 percent of the world's electricity fuel market, slightly lower than its 36-percent share in 1999. The United States accounted for 35 percent of all coal use for electricity generation in 1999 and developing Asia 31 percent. In the *IEO2002* forecast, the coal share of U.S. electricity generation is expected to decline to 46 percent in 2020 from 51 percent in 1999; and in developing Asia the coal share is projected to decline to 51 percent in 2020 from 62 percent in 1999. Although coal remains a relatively inexpensive fuel for electricity production, natural gas is generally regarded as being environmentally superior, and the improving economics of natural gas generation technology also suggest that natural gas will gain market share.

Reliance on coal for electricity generation is also expected to be reduced in other regions. In Western Europe, for example, coal accounted for 23 percent of the electricity fuel market in 1999 but is projected to have only a 15-percent share in 2020. Similarly, in Eastern Europe and the FSU (EE/FSU), coal's 23-percent share of the electricity fuel market in 1999 is projected to fall to 11 percent by 2020. For years, massive state subsidies were all that kept many Western and Eastern European coal mines in operation. In many cases, the subsidies were underwritten by electricity consumers. Europe's dependence on coal as a source of electric power generation has waned with the gradual diminution of state subsidies.

Nuclear Power

The nuclear share of energy use for electricity production is also expected to decline in many regions of the world as a result of operational safety concerns, waste disposal issues, concerns about nuclear arms proliferation, and the economics of nuclear power. In 2020, nuclear power is projected to capture 12 percent of the electricity fuels market worldwide, down from 16 percent in 1999. In many nations, the projected move away from nuclear power has slowed in the past several years. In the United States, for example, several nuclear utilities have been granted license extensions for their nuclear power reactors. Moreover, in the United States and the United Kingdom, several nuclear utilities have announced their intentions to build new units in the future.

In the United States, the nuclear share is projected to drop from 20 percent of the electricity fuel market in 1999 (second behind coal) to 13 percent in 2020. In Canada, where the nuclear share of the market has been declining since 1984, its 14-percent share in 1999 is projected to remain stable. In Western Europe, the nuclear share of the electricity fuel market is projected to fall from 35 percent in 1999 to 24 percent in 2020—more than any other energy source. (Finland and France are alone among Western Europe's nuclear power producers in remaining committed to expansion of their nuclear power programs.)

In Japan, nuclear power accounted for 33 percent of the energy used for electricity generation in 1999. That share is expected to rise to 37 percent by 2020 in the *IEO2002* forecast. In the EE/FSU region, the nuclear share is projected to decline from 12 percent in 1999 to 9 percent in 2020.

Nuclear power contributes very little to electricity generation in the developing nations of Central and South America, Africa, and the Middle East, and it is expected to contribute little in 2020. Among South American nations, only Argentina and Brazil were nuclear power producers in 1999. In Africa, only South Africa generated electricity from nuclear power in 1999. There are no nuclear power plants in operation in the Middle East, although one is under construction in Iran.

In contrast to the rest of the world's regions, in developing Asia nuclear power is expected to play a growing role in electricity generation. China, India, Pakistan, South Korea, and Taiwan currently have nuclear power programs, and the nuclear share of the region's electricity fuel market is expected to remain stable at 6 to 8 percent from 1999 through 2020. China is expected to account for most of the region's nuclear power capacity additions.

Hydroelectricity and Other Renewables

Renewable energy, particularly hydropower, accounted for 20 percent of the world's energy use for electricity generation in 1999, where it is expected to remain in 2020. Of the world's consumption of renewable energy for electricity production in 1999, the United States and Canada together accounted for almost 26 percent of the total, Western Europe 19 percent, and Central and South America 19 percent (despite consuming just 5 percent of the world's electricity).

In 1999, renewables accounted for 11 percent of electricity production in the United States and 62 percent in Canada, both nations where hydroelectric power has

been extensively developed. The renewable shares of electricity generation are expected to decline in both countries over the forecast period, the U.S. share to 9 percent and the Canadian share to 54 percent. In North America and throughout the world, generation technologies using nonhydroelectric renewables are expected to improve over the forecast period, but they still are expected to be relatively expensive in the low price environment for energy fuels assumed in the *IEO2002* reference case.

Hydroelectricity is most widely used for electricity generation in Central and South America, and renewables accounted for 75 percent of the region's electricity fuel market in 1999. However, recent experiences with drought, cost overruns, and the negative environmental impacts of several large-scale hydroelectric projects have reduced the appeal of hydropower in South America. The renewable share of electricity generation in Central and South America is expected to decline to 55 percent by 2020 as the region works to diversify its electricity fuel mix.

Most of Western Europe's renewable energy consumption consists of hydroelectricity. Renewables in total accounted for 22 percent of the region's electricity market, and their share is expected to increase to 26 percent in 2020. Some European nations, particularly Denmark and Germany, are actively developing their nonhydroelectric renewable energy resources, most notably wind.

Some near-term growth in renewable energy use is expected in developing Asia, particularly in China, where the 18,200-megawatt Three Gorges Dam and a number of other major hydropower projects are expected to become operational during the forecast period. Developing Asia relied on renewables for 16 percent of its electricity production in 1999, and that share is expected to grow to 19 percent by 2020.

Oil

The role of oil in the world's electricity generation market has been on the decline since the second oil price shock that started in 1979. Oil accounted for 23 percent of electricity fuel use in 1977, but in 1999 its share was under 10 percent. Energy security concerns, as well as environmental considerations, have led most nations to reduce their use of oil for electricity generation. However, in regions where oil continues to hold a significant share of the generation fuel market, such as the FSU and the Middle East, it is expected to continue to play a relatively prominent role. As a result, the oil share of world energy use for electricity production is projected to slip only slightly, to 9 percent in 2020.

Developing Asia accounted for 17 percent of the world's consumption of oil for electricity generation in 1999, when 9 percent of its electricity fuel use consisted of oil (down from 29 percent in 1977). The oil share of electricity fuel consumption in developing Asia is expected to remain stable through 2020. In the petroleum-rich Middle East, oil supplied 35 percent of the energy used for electricity generation in 1999, and its share is projected to fall to 24 percent in 2020, as these countries continue to build their reliance on natural-gas-fired generation.

Project Finance in the Developing World

Developing countries are expected to see their electricity consumption grow at a 4.2-percent annual rate through 2020 (Table 20). In order to achieve such growth, billions of dollars in capital investment will need to be raised.

There are numerous methods available for the financing of power projects in developing countries (for example, see box on page 132). These methods allow for various levels of participation and control by private (and sometimes foreign) investors. They range from management and operations contracts to greenfield projects to full divestitures:

- Management and operation contracts involve an outside private entity managing but not owning a public entity—often for a specified period of time. They involve the state ceding the least amount of control to private enterprise.
- Greenfield projects involve the construction of new power plants by private investors or by public-private ventures. They may be build-own-operate (BOO), build-operate-transfer (BOT), or build-lease-own (BLO) agreements [***1***].
- Divestitures fall on the other end of the spectrum from management contracts, allowing for a much deeper level of involvement as the private firm takes a substantial equity stake in what was a domestic (and sometimes publicly owned) enterprise.

The most common forms of financing are debt and equity. In the case of power projects, debt usually consists of commercial bank loans or bond issuances. Equity, on the other hand, usually consists of taking stock or ownership in the project or company. One instrument that blends the qualities of debt and equity is a subordinated loan, which is given "repayment priority over equity capital, but not over commercial loans or other senior debt" [***2***].

Another concern for investors in developing countries involves the claim that various loans and bonds have on the assets and cash flows of the project developer in the event of a default. Financing has ranged from traditional corporate finance to the now popular project finance. Traditional corporate lending usually involves the power project being backed by the sponsor's balance

Micro-Credit for Micro-Electricity in Bangladesh

A major impediment to providing much of the developing world with access to electricity has been the inability to obtain financing for the necessary infrastructure. The Grameen Bank (Village Bank) is a nongovernmental organization that has been providing micro-credit loans[a] to rural inhabitants of Bangladeshi villages since 1976. The loans are used to finance small business activities, such as raising chickens, producing handicrafts, and operating cellular phone centers. They have been extremely successful in improving the lives of the rural poor in Bangladesh, and the concept has been replicated in many other countries of the world, including the United States. In 1996, the Grameen Bank established a subsidiary called Grameen Shakti (Village Power), with the intent of providing renewables-based electrification opportunities for rural populations.

The concept of the Village Power program is simple: to extend micro-credit opportunities that would allow rural households and commercial establishments the opportunity to finance renewable energy systems. For electricity consumers in developing countries, a typical 50-watt photovoltaic system costs about $450,[b] including photovoltaic panels, switches, outlets, wiring, a charge controller, end-use devices, and a battery. (On rainy days or in overcast weather the battery can provide backup power for a few days). In Bangladesh, 50-watt systems provide enough power to operate four 6-watt compact fluorescent lights, a black-and-white television, or a few small fans.[c] This amounts to a significant amount of power for most rural households in Bangladesh, which currently have few existing means of connecting to power providers. Bangladeshi villagers either do without electricity (which is the prevalent option for most) or, if they are wealthy enough to afford it, purchase 2 or 3 car batteries, which must then be transported several miles by hand to the nearest market for periodic recharging.

Traditionally, rural lenders in countries such as Bangladesh have charged poor local villagers and farmers a steep premium over the interest rates charged by more established financial institutions operating in urban areas. Rates charged to villagers in Bangladesh have exceeded 150 percent.[d] Part of the premium could be justified on the basis of the *real* creditworthiness of the two borrowers; part could also be ascribed to the relatively large transaction costs that accompany small-scale lending. However, part can also be attributed to "knowledge asymmetry," which prevents market penetration by outsiders into the business of lending to rural villagers and provides justification for local monopoly. Other potential lenders include indigenous commercial banks and even foreign financial intermediaries, but they lack the intimate knowledge that local moneylenders have about the local business climate, such as which individuals have the industriousness and thrift habits that would make them desirable clients. These habits could easily be well known to local lenders living in the community but a mystery to outsiders.[e]

The Grameen Bank managed to surmount this hurdle in several interesting ways. In order to qualify for a Grameen Bank loan, potential borrowers must form a group. Peer pressure is thus exerted to make borrowers comply with the agreed-upon repayment arrangement, as any noncompliance is made public to the group. Family members are excluded from joining the same group. Interestingly, 90 percent of loan recipients are female.[f]

Small-scale photovoltaic systems have been installed in many places around the world. Grameen Shakti's innovation (at least in Bangladesh) was in arranging a marriage between micro-credit and renewable micro-energy. The $450 cost of a photovoltaic system is an expensive proposition in a country where annual

(continued on page 133)

[a]Micro-credit loans are small loans (average amounts are about $100) that are provided to the poorest of poor in rural areas. The loans are provided in lieu of a business plan that the recipient has to present to show how the loan would be utilized. More than 90 percent of Grameen's borrowers are women. Loans are made to individual women, who help each other with repayment issues.

[b]Personal communication with Mr. Dipal Barua, Managing Director, Grameen Shakti, October 23, 2001.

[c]Dipal Barua, "Energy's Role in Rural Income Generation: The Grameen Strategy," Presentation at Village Power Workshop 1998 (Washington, DC, October 1998).

[d]H.R. Varian, "Economic Scene: In a Market for Lending in Developing Nations, a Bangladesh Bank Relies on Peer Pressure for Collateral," *The New York Times* (November 22, 2001), p. C2.

[e]One seminal study, which among other things, analyzed the causes for the wide interest gap charged to Indian villagers relative to rates charged by large banks in central cities, attributed this gap in part to the asymmetry in knowledge possessed by traditional rural moneylenders over outsider financial intermediaries, thereby preventing outsiders from penetrating into their territory. See G.A. Akerlof, "The Market for Lemons: Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, Vol. 94, No. 3 (August, 1970), pp. 488-500.

[f]H.R. Varian, "Economic Scene: In a Market for Lending in Developing Nations, a Bangladesh Bank Relies on Peer Pressure for Collateral," *The New York Times* (November 22, 2001), p. C2.

sheet. In contrast, project finance separates the project's balance sheets from those of the sponsor company [***3***]. In this form of financing, only the revenues from the project are slated to pay the equity holders and creditors; in other words, the project investors can only lay claim to the project's cash flows and assets and not the cash flows and assets of the sponsor's other operations. This is known as nonrecourse financing. Most projects in developing countries combine both forms of backing in what are called limited recourse projects. Limited recourse projects might involve some additional backing, such as a pre-completion during the project's construction period, or a government or sponsor guarantee [***4***]. Whereas traditional corporate debt is beneficial in that it allows borrowers to pay lower rates of interest, nonrecourse and limited recourse financing expose investors to less risk.

The selected project financing technique depends heavily on the creditworthiness of the country where the investment is taking place. Legal systems, economic and financial environments, and political stability are some of the factors that determine a nation's creditworthiness. The most obvious method for repayment of the costs of a power plant would be through the cash flow from the operations of the plant. However, many developing countries are plagued by theft of electricity or tariff rates that cannot support the cost of the plant. For riskier projects, state Export Credit Agencies (ECAs) often play a role in providing loans, making guarantees to financiers of the project, or acting as an insurance facility. Developing countries are also recipients of major funding packages from multilateral and bilateral agencies or credit facilities, which have a function similar to that of ECAs.

Among world regions both Asia and Latin America stand out as major targets of private investment in electricity during the 1990s. During the 1990s, Latin America's power sector attracted $78 billion in private investment (Figure 76). Seventy-one percent of that investment consisted of equity (Figure 77). Latin American countries have been pioneers in privatization, not only in the power sector but also in pension systems, telecommunications, etc. Among Latin American nations, Chile has been a leader in privatization and was the first to privatize and unbundle electricity generation, transmission, and distribution within the electricity industry. Chile was also a trailblazer in allowing foreign investment in its domestic electricity sector. Currently, Chilean electricity companies are investing in the power sectors of other Latin American countries. Argentina followed Chile's reform with a wholesale privatization and restructuring of the nation's electricity sector. In some Latin American nations, all segments of the electricity industry have been opened to private investment from

Micro-Credit for Micro-Electricity in Bangladesh (Continued)

per capita income is about half that. To provide villagers access to the necessary capital, the micro-finance aspect of Village Power involves a loan package under which households have the option of making a 15-percent down payment and paying the remainder over a 2-year period at an annual interest rate of about 12 percent. Grameen Shakti provides all the necessary equipment and meets service needs for one year—in effect, acting as a mini-utility.

There are a number of energy applications to which micro-credit financing mechanisms have been applied:

- Operation of a soldering iron to repair radios and televisions
- Residential and commercial lighting, which allows children to study at night and laborers to work past sunset
- Cellular phone charging and "renting out" phone services to allow surrounding villagers to communicate with the outside world
- Biodigesters to produce methane gas for cooking and fertilizer.

To date, the Grameen Shakti photovoltaic program in Bangladesh has been successful. An interesting aspect of the program has been the creativity that has been shown by borrowers. As loan recipients have had the opportunity to experience the benefits of renewable energy systems, they have developed innovative applications for the energy, which have helped sustain the micro-energy program in Bangladesh. For example, one loan recipient installed a solar-based mini-grid to supply electricity to shops in the village market.

As of September 2001, Grameen Shakti had installed 5,800 photovoltaic systems representing 290 kilowatts of capacity.[g] In addition to continuing the sale of photovoltaic systems for residential lighting applications, the organization plans to expand the use of renewable energy systems to commercial activities that will generate income for villagers. It has installed and is successfully operating five solar-powered computer education centers at remote areas. Most importantly, however, the micro-credit loan programs have been able to improve the standard of living for many impoverished Bangladeshi without access to traditional electricity services or financial intermediaries.

[g]Personal communication with Mr. Dipal Barua, Managing Director, Grameen Shakti, October 23, 2001; and Grameen Shakti, "Programs: Photovoltaics (PV) Program," web site www.grameen-info.org/grameen/gshakti (September 10, 2001).

generation to transmission to distribution. Municipally owned, state-owned, and nationally owned utilities have been wholly privatized and, in some instances, sold to foreign investors.

On the other end of the spectrum, developing Asian countries have generally not engaged in deep power sector reform and typically have chosen to rely more on independent power providers (IPPs) that outsource to the public grids. In contrast to Latin America, Asia's electricity sector, which attracted a greater $93 billion in private investment between 1990 and 1999 (Figure 76), saw 72 percent of that investment directed to greenfield projects (Figure 77). Private-sector involvement generally has been limited to generation; transmission and distribution have traditionally been in the hands of the government. Private-sector participation in Asian electricity industries has focused on greenfield projects of IPPs, which bring in large amounts of new generation and foreign investment. This has sometimes led to serious problems, however, as the highly politicized issue of determining fair tariff rates discourages the ability to raise enough revenue to support the cost of generation without the aid of government subsidies. Recent controversial private electricity investments such as the Dabhol/Enron arrangement (see box on page 135) has led to some debate about the most suitable forms of privatization and financing for various regions.

World Electricity Deregulation

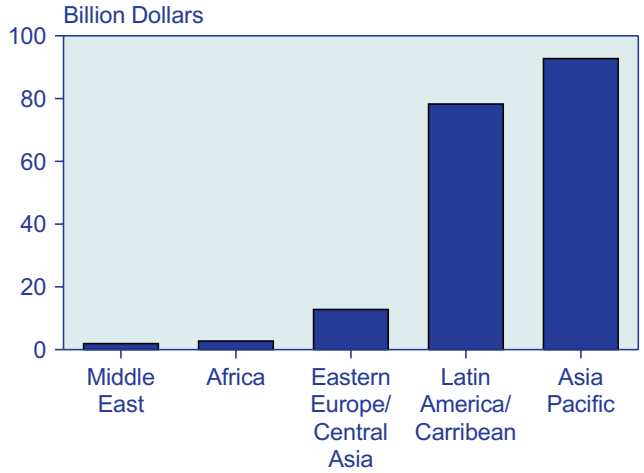
Recent efforts at electricity reform could be included as one of the most significant global energy developments of the past century. Since the mid-1990s, more than 30 countries or regions within countries have attempted significant electricity reform measures [***5***].

In those developed nations where electricity assets have been publicly owned, privatization (and its weaker cousin, corporatization[19]) has been a major element of reform. Many industrialized nations have also for the first time opened their doors to foreign investment. For the most part, however, electricity reform in the industrialized world has involved a restructuring of the industry along the lines of its different functions, as well as a rewriting of the rules under which participants in electricity markets operate. The restructurings and rule changes vary among countries, but several similarities stand out.

Recent efforts at electricity reform can be traced to developments that occurred more than two decades ago. The United States embarked on an opening up of its electricity market to new entrants with the passage of the Public Utilities Regulatory Policies Act of 1978. Countries such as Chile (which started its reform in 1982), New Zealand (1987), Norway (1991), and Argentina (1992) were also early reformers. However, the United Kingdom, which embarked on sweeping privatization and restructuring of its electricity sector beginning in 1989, was the pioneer for reforms elsewhere.

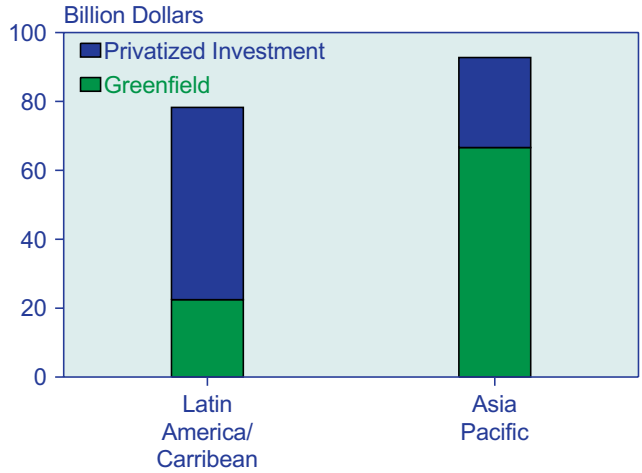
In countries with federalist forms of government, state or provincial governments have often led the way in electricity sector reform. In Australia, for instance, reforms in the state of Victoria predated national reforms. Similarly, in Canada, the province of Alberta (1996) was the first province to adopt electricity reform

Figure 76. Cumulative Private-Sector Investment in Electricity Among Developing Regions, 1990-2000



Source: Public Policy for the Private Sector, World Bank Data Base.

Figure 77. Cumulative Total Investment in Electricity Projects in Asia and Latin America, 1990-1999



Source: Public Policy for the Private Sector, World Bank Data Base.

[19]Corporatization maintains public ownership but allows management autonomy. The separation between the state and management of the entity is imposed in order to force the entity to behave more like a competitive business.

India's Dabhol Power Project

Domestic capital shortages in recent years have led some developing nations to open up their domestic electricity markets to foreign investors. In the early 1990s, a consortium led by U.S.-based Enron Corporation[a] began negotiations with the state government of Maharashtra in India for Enron to build an electricity generation plant near Dabhol, 180 miles south of Mumbai (formerly Bombay). The Maharashtra State Electricity Board (MSEB)[b] finalized an agreement that led to the creation of the Dabhol Power Corporation in June 1992. Since then, the project has progressed precariously, and serious contractual issues have arisen between Enron and the host state. Currently, the project is at a standstill.

Electricity reform in India began shortly before the Dabhol project was initiated. In 1991, a balance of payments crisis that followed a decade of economic isolationism prompted the Indian government to liberalize the nation's foreign investment policies. To attract foreign investment, India encouraged private-sector involvement in public-sector enterprises, including electricity generation. India's central government relaxed previously stringent measures in order to jump-start major power projects, known as the "fast track projects."[c]

Dabhol, the first of India's fast track projects, got off the ground with a memorandum of understanding between Enron and the MSEB in June 1992. The understanding called for the construction of a 2,015-megawatt power plant. The original power purchase agreement (PPA) between Enron and Dabhol was signed for the first of two phases in December 1993. In Phase I, imported distillate was to be used to fuel the new power plant while construction of a receiving terminal and regasification facility for liquefied natural gas (LNG) was being completed. In Phase II, the power plant would be fueled with natural gas from the LNG import terminal. The agreement required the MSEB to buy 90 percent of the plant's baseload generation at 7.5 cents per kilowatthour for 20 years after commissioning.[d] Both fuel price fluctuation risk and foreign exchange risk were assumed by the MSEB.

Concerns about the project were raised in 1995 when a new government represented by the Shiv Sena and the Bharatiya Janata Party (BJP) coalition party[e] came into office in Maharashtra after conducting a campaign marked by economic nationalism. A review committee, headed by Gopinath Munde, former deputy chief minister of Maharashtra, was formed to examine the PPA contract along with other parameters of the project. The committee's report raised concerns about the project's potential environmental damage, the fact that the initial contract negotiation lacked competitive bidding and public scrutiny, and the reasonableness of the project's capital costs. It also noted that the World Bank had recommended using the plant for peak load and had suggested that another fuel source, such as coal or naphtha, would be more suitable than natural gas.[f]

In June 1999, the Maharashtra government initiated the cancellation of the Dabhol project.[g] In response, Enron agreed to a renegotiated contract that called for, among other things, a new PPA that attempted to resolve a number of the review committee's concerns. The total capacity of both project phases was increased (from 695 megawatts to 826 megawatts in Phase I and from 1,320 megawatts to 1,624 megawatts in Phase II), with the additional generating capacity to be provided by Enron at no additional cost. The power purchase charge—although still subject to fuel price and exchange rate fluctuations—was lowered from 7.5 cents to 6.0 cents kilowatthour. The capital cost charge was lowered by excluding the cost of the regasification facility, which was to be included instead in the cost of the fuel. There was a reduction in the foreign exchange component of payments to Enron by 400 billion rupee (about $8.4 billion), and the MSEB was given an equity stake of 30 percent in the project. The project's fuel was switched to cheaper domestic naphtha for Phase I until commissioning of Phase II. More environmental provisions were agreed to, and employment was to be provided for one member of each family displaced by the project's construction site.[h]

(continued on page 136)

[a]Enron's partners included Bechtel Enterprises Holdings, Inc., and GE Capital Structured Finance Group, which were equity holders; various domestic and international financial institutions also supported the project through loans.

[b]SEBs are state electricity boards which are in charge of providing generation, transmission, and distribution by coordinating with both public and private players involved both at the state and central level.

[c]Fast track projects were power projects of at least 1000-megawatt capacity and were given clearance much faster than normal power projects as a means of attracting foreign investment.

[d]K.S. Parikh, "Thinking Through the Enron Issue," *Economic and Political Weekly* (April 28, 2001). This charge included the capital charge, operating and fuel charges.

[e]The Congress Party was in office when the original proceedings occurred, and it was pro-liberalization. Coalition parties often are formed among India's many diverse political parties.

[f]"India: Dabhol Power Project," web site http://altindia.net/enron/Home_files/WBnote.htm (April 30, 1993).

[g]"Munde Sub-Committee Report," web site www.hrw.org/reports/1999/enron/enron-b.htm.

measures. In the United States, the State of California (1998) had been at the forefront of State-initiated electricity reforms; however, the State has now begun to "re-regulate."

Much of the electricity reform undertaken in various countries has been motivated by similar issues, including the following:

- Technological developments, particularly those related to the growing efficiency of natural gas turbines
- Investment shortages, particularly among developing countries
- High electricity prices
- A rethinking of the notion of electricity supply as a natural monopoly.

Technological Developments

For most of the last century, reductions in the cost of electricity generation were achieved through the building of larger and larger generators, which in essence supported the view that electricity generation was a natural monopoly.[20] In recent years, however, developments in natural gas technology have reversed that trend, allowing maximum efficiencies to be realized at lower and lower generation capacity levels. Almost all new generation capacity added in the United States currently is gas-fired. Gas-fired capacity offers several technological advantages over its alternatives. and—at all but the lowest interest rates—is more competitive than coal. Today, a state-of-the-art combined-cycle natural gas unit is more efficient than coal or nuclear units. Gas-fired plants also have shorter startup times. The time needed to build a natural-gas-fired generation unit averages 2 to 3 years, compared with 3 to 5 years for coal

India's Dabhol Power Project (Continued)

The new PPA became legally binding in August 1996, and Phase I began operation in 1999. The new contract soon ran into trouble, however. In July 2000, the average price of power from the Dabhol project rose sharply, following a depreciation of the rupee against the U.S. dollar and an increase in natural gas prices from 1999 to 2000. Early in 2001, the MSEB defaulted on its November electricity bill. The bill was eventually paid by the MSEB with assistance from the state government, but Phase I of the project was shut down, and construction on Phase II was halted.

A new energy review committee, chaired by Madhav Godbole, former chairman of the MSEB, was established by the Maharashtra state government. The committee's mandate was to review the electricity situation and particular electricity projects, including Dabhol. The review committee submitted Part I of the report on April 10, 2001.[i] It concluded that the Dabhol Power Corporation was overcharging the MSEB in terms of the regasification facility, shipping and harbor costs, operating and maintenance costs, and fuel consumption. Several guidelines were recommended to reduce the tariff and liability of the project.

The project hit another obstacle when the parent corporation, Enron, after tumbling into a financial abyss, filed for bankruptcy in December 2001. Enron's share prices declined from $85 one year earlier to 26 cents by late 2001.[j] As a consequence, in December 2001, the Dabhol Power Corporation laid off 200 of its remaining employees. Many different approaches to the Dabhol project's financial difficulties are currently being entertained. Various entities that have been involved have stepped forward to offer possible solutions, including the World Bank and various other financial institutions, as well as external parties new to the scene, including domestic rivals Bombay Suburban Electric Supply and Tata Power Company, as well as other global energy giants that may seek to fill the role left vacant by Enron's apparent demise.

Whatever its eventual outcome, the drama of the Dabhol project has exposed some of the ills of India's electricity system. According to R.K. Pauchari, director of the Tata Energy Research Institute, electricity reform could add 1 to 2 percent to India's Gross Domestic Product "almost instantly," and although reform has occurred at different levels in a handful of states (Orissa, for example) widespread reform is still in the early stages.[k] The project has also exposed some of the difficulties foreign companies face in investing in countries currently making a transition toward freer market economies.

[h]J.W. Salacuse, "Renegotiating International Project Agreements," *Centre for Energy, Petroleum and Mineral Law and Policy Internet Journal*, web site www.dundee.ac.uk/cepmlp (August 2001).

[i]The report can be found at web site www.maharashtra.gov.in/english/energy/rerc.htm. Part II was published September 2001 and focuses mostly on the general sector reform.

[j]K.M. Kristof, "Bankruptcy of Energy Trader May Hurt Many," *Los Angeles Times* (December 3, 2001).

[k]"Red Tape and Blue Sparks: A Survey of India's Economy," *The Economist*, Vol. 359, No. 8224 (June 2, 2001), pp. 9-14.

[20]A natural monopoly is desirable in a situation where one firm can produce a given level of output at a lower total cost than can any combination of multiple firms.

plants. In many countries nuclear power plants, if still an option, would take even more time to construct than a coal-fired plant.

Natural gas plants are also more flexible. The maximum efficiency of a gas-fired power plant is achieved at a much smaller level of capacity than a coal-fired unit. This feature increases the attractiveness of natural-gas-fired units, because the size of a new natural gas plant being introduced can be adapted readily to various changes in demand, and it can be built closer to the location where those changes are taking place. For all these reasons, future new capacity additions no longer need to be the domain of large utilities, and indeed no longer need to be in the domain of utilities at all. In both the United States and the United Kingdom, the move to natural gas has done much to foster an independent power generation industry—an industry less subject to government regulation than are traditional utilities.

Investment Shortages in Developing Countries

In the developing world, a lack of access to capital has in many instances hindered investment in electricity infrastructure. As a result, many countries have opened their electricity sectors to more direct forms of investment from overseas. This has been particularly true in the case of countries that suffered most during the widespread debt crisis of the 1980s. In Latin America, where economic growth and investment languished throughout most of the period, the 1980s were know as the "lost decade." Moreover, during the 1980s, financial institutions, in particular commercial banks, incurred severe losses from loan defaults among developing nations, which may have had a limiting impact on the developing world's access to some world capital markets and may have driven developing countries to allow greater direct investment from abroad. Another reform measure, which was commonly employed by developing countries in Asia, was to open up domestic electricity sectors to greenfield investments by foreign sources.

High Electricity Prices

Electricity prices vary considerably across regions and countries. Some of the variation can be accounted for by the degree of access to relatively cheap forms of electricity. For instance, in Norway, which relies on relatively cheap hydropower for almost all its electricity, electricity prices typically have been relatively low by industrial world standards [***6***]. The same is true of the Pacific Northwest of the United States, where colossal dams, many of which were built during the 1930s, provide relatively cheap sources of electricity.

Regional and national electricity prices also vary considerably with the ownership structure of the industry and the degree of regulation. The resulting price differentials can have a significant effect on a region or area's degree of competitiveness. They can also affect real standards of living. Many high-cost electricity countries, provinces, and U.S. States were among the earliest reformers. For instance, in 1995 electricity prices in California were 43 percent higher than the U.S. average [***7***], and industrial electricity prices in Germany were 15 percent higher than in the Organization of Economic Cooperation and Development (OECD) as a whole (Table 22).

Monopoly Industry and Competitive Industry

Another aspect of electricity reform is a rethinking of the notion that electricity supply is a natural monopoly. The rethinking has focused mostly on the generation

Table 22. OECD Industrial Electricity Prices, 1990-2000
(1999 Dollars per Kilowatthour)

OECD Country	1990	1995	1999	2000
Australia	0.042	0.048		
Austria	0.053	0.060	0.056	
Belgium	0.054	0.055		
Canada	0.032			
Czech Republic	0.101	0.149	0.121	0.125
Denmark	0.041	0.046	0.053	0.054
Finland	0.038	0.045	0.042	0.041
France	0.046	0.046	0.040	0.039
Germany	0.071	0.071	0.052	
Greece	0.073	0.071	0.061	
Hungary	0.180	0.093	0.124	0.129
Ireland	0.059	0.064	0.059	0.056
Italy	0.082	0.097	0.093	0.117
Japan	0.091	0.103	0.101	
Korea	0.092	0.093	0.101	0.112
Mexico	0.074	0.059	0.069	0.079
Netherlands	0.044	0.059	0.061	0.068
New Zealand	0.036	0.040	0.038	0.035
Norway	0.023			
Poland	0.080	0.084	0.075	0.081
Portugal	0.135	0.148	0.116	0.113
Spain	0.091	0.083	0.067	
Sweden	0.033	0.029		
Switzerland	0.056	0.074	0.073	0.075
Turkey	0.144	0.156	0.170	0.187
United Kingdom	0.066	0.066	0.059	0.056
United States	0.047	0.047	0.044	0.045
OECD Europe	0.067	0.070	0.060	0.047
OECD Total	0.062	0.062	0.057	0.040

Notes: Prices were calculated using purchasing power parities. Some data points are missing, because not all countries provide price information of each year.

Source: International Energy Agency, *Energy Prices & Taxes, Quarterly Statistics* (Paris, France, Fourth Quarter 2001); and Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035 (Washington, DC, various issues).

side of the business and the relatively new business of electricity marketing. As mentioned earlier, with the economics of the industry changing in favor of smaller and smaller generation units, the opportunities for competition among different companies have grown. As a consequence, in many instances, countries have fully or partially liberated the generation side of the business from regulatory constraints while retaining regulation for the "wires" (transmission and distribution) side of the business. Competition in generation has also led to the creation of electricity pools, along with various hedging markets.

Global Electricity Reform

Various states, provinces, countries, and regions have undertaken efforts to reform their electricity sectors over the past two decades or so. Some of the reform efforts bear similarities; some have been unique. In general, however, the different paths to reform have involved one or more of the following actions:

- Unbundling of electricity assets through divestiture, or a vertical separation of ownership, and/or control, of certain electricity assets in order to promote competition, particularly in generation
- Creation of electricity trading arrangements (pools)
- Creation of independent system operators (ISOs) and, in the United States, regional trading organizations (RTOs)
- Privatization of electricity assets through sale or public auction, or the corporatization of the governance of the assets
- Deregulation of electricity prices and the implementation of a more restrained (light-handed) form of regulation where regulation was retained
- Open access to the grid
- Opening up of domestic electricity assets to foreign investment
- Retail competition.

Unbundling

Unbundling of electricity operations generally involves one of two approaches: (1) a separation of ownership of the various forms of electricity supply, i.e., generation, transmission, distribution, and marketing; or (2) a separation of control of the various forms of electricity supply. There are several motivations behind unbundling. One is to separate the potentially competitive elements of the business from those still bearing monopoly characteristics. Another is to offer various services with various price schedules, thus pricing various aspects of electricity supply at their costs of production, which adds greater transparency to electricity prices and enables consumers to make price comparisons.

In one form or another, most electricity reform around the globe has involved an unbundling of energy services. Several nations have attempted to achieve this goal through a vertical separation of ownership of various segments of the electricity industry. In Australia, Argentina, the United Kingdom, and the United States, unbundling involved the breaking up of vertically integrated utilities along their separate lines of business, creating distinct and separate corporate entities. In New Zealand, most of Western Europe, and the Nordic countries (Denmark, Finland, Norway, and Sweden), unbundling has generally involved the separate pricing of various electricity services and sometimes instituting an accounting separation between the different segments of electricity supply.

The United Kingdom was the first country to divest generation from distribution and transmission, which it accomplished in 1990. In the United Kingdom, the former government-owned power company (which included generation, transmission, and distribution assets) was separated during privatization into two generation companies, along with a transmission company and 12 distribution companies. A similar separation was instituted in Australia. As part of its reform efforts, California required its three major vertically integrated utilities to shed half their generation assets, which were largely sold off to independent power producers.

Another means of instilling more competition in generation involved not the separation of ownership but the separation of control. For instance, New Zealand separated transmission from distribution (although both remained government owned) and created two state-owned electricity generation companies so that they could compete against each other. Similar accounting separations occurred in Finland, Germany, Ireland, Portugal, and Spain [***8***].

Electricity Pools

Another important element of electricity reform involves the development of wholesale electricity trading arrangements, or electricity pools. In the past, most electricity was sold in bilateral forward markets. Several efforts at reform have initiated the introduction of pools to electricity exchanges. In several instances, electricity pools have been quite volatile. This volatility can serve a purpose in some market structures (e.g., by reducing demand or signaling a need for greater investment), but in others it has led to unwanted swings in earnings and prices to consumers. In order to deal with these and other complexities, various market designs have been employed by various countries and various regions in creating their electricity pools. These have sometimes included a variety of different trading arrangements: real-time pricing, day-ahead pricing, forward markets, and various hedging tools, such as futures markets and contracts for differences markets.

Although no two pool arrangements are identical, several share some similarities. In some cases, participation in electricity pools has been made mandatory, as initially was the case in Australia and the United Kingdom, or non-mandatory, as is the case in New Zealand, Nord Pool, Spain, and the Pennsylvania-New Jersey-Maryland pool (PJM) [***9***]. In several instances, unregulated bilateral markets have operated side by side with the pools, as in the United Kingdom, New Zealand, and the Nordic countries, or have been discouraged, as was the case in California. In some cases, prices have been set beforehand (as in the United Kingdom and Nord Pool), or by estimated supply and demand. In other cases, prices have been set after the market has cleared (as in Australia and New Zealand) or by actual supply and demand [***10***].

An important issue in the development of electricity pools involves ownership and / or corporate governance and the relationship of the pool to the entities that generate, transmit, and distribute electricity. Although electricity pools have existed in the United States since the late 1960s, the United Kingdom was the first to create a nationwide electricity pool, which has been in operation since 1990. In many ways the structure of this pool was copied elsewhere. Initially, the UK electricity pool was operated by the privately held National Grid Company, which was also responsible for electricity transmission. In turn, the National Grid Company was initially owned by 12 regional distribution companies (which were forced to divest their shares in 1995, when the National Grid became a separate, privately held concern). Similar organizational structures emerged in Sweden and Norway, where both system operation and pool operations fell under one umbrella organization [***11***]. In other countries and regions, ownership and / or control of the transmission system was separated from ownership and / or control of the electricity pool. This was true in Victoria (Australia) and California, where separate power exchanges were created in order to separate operation of the transmission system from operation of the pool.

Various countries have taken other approaches to pool ownership. In Alberta, Canada, the pool is operated on a cooperative basis governed by a council of pool participants [***12***]. In Finland, the power exchange was initially owned by a Securities and Derivatives Exchange. In New Zealand, the wholesale market is owned by the government-owned generation utility, the Electricity Marketing Company (EMCO). The PJM power pool is owned by 10 primary members, which are vertically integrated utilities.

Another important element of electricity pools is the rules under which they operate. The UK Pool (as it was initially set up), in some ways set the framework for many pools to follow. In order to balance electricity supply and demand, the UK government instituted a power pool to act as a clearinghouse between suppliers of electricity (generators) and wholesale consumers of electricity (primarily the regional electricity distribution companies).

In the UK Power Pool, every day was broken up into 48 half-hour segments. The system manager forecast demand for each half-hour segment. Twenty-four hours in advance, generators submitted bids for the various levels of power they were willing to supply at various prices and for various periods, for each half-hour period of the following day. The system manager then ranked the bids from least to most expensive. The system manager also calculated the minimum amount of generating capacity needed to meet demand projections. A merit order dispatch schedule was created, with the cheapest generation units selected first and supply capped when enough generation units were selected into the system to provide sufficient generation capacity to supply one unit of energy over and above the demand forecast [***13***].

The Pool purchase price for all suppliers was set by the highest bid from the last generation facility needed to accommodate the last unit of demand. This balancing activity was an attempt to arrive at the electricity generation industry's marginal cost, or the system marginal price (SMP). The price actually paid to generators also included a financial incentive (capacity payment) for maintaining some additional (peak load) generation capacity in the event that demand exceeded the consumption forecasts. This merit order system of estimating a supply / demand equilibrium has been duplicated elsewhere. Argentina and California have adopted similar mechanisms to set market clearing prices.

In the United Kingdom, as a means of controlling price volatility, a hedging market developed. This market, called the contract for differences market (CfD), allowed for bilateral contracts to be negotiated between generators and consumers. In the CfD market, generators and electricity purchasers could hedge Pool prices by committing to a contract with an agreed-upon price (the strike price). The strike price, for instance, might be set at an average of expected daily Pool prices. If the strike price turned out to be higher than the daily average Pool price, then the generator paid the purchaser the difference. Conversely, if the strike price turned out to be lower than the daily average Pool price, the electricity purchaser reimbursed the generator for the difference. In reality, the CfD market used a variety of different hedging contracts. Contracts for differences were purely financial contracts. A contracts for differences market also emerged in Australia.

In early 2001, the United Kingdom shut down the Pool and embarked on a new form of electricity trading,

called the New Electricity Trading Arrangement (NETA). This was done because it was felt that the old pool arrangements failed to foster adequate competition. Even after the UK generation market was broken up during the mid-1990s, the Pool was still highly concentrated (Table 23). Devising trading arrangements suitable to a commodity with such unusual features as electricity has been a problem that has dogged deregulators in several countries, states, and provinces. In several ways, NETA comes closer to resembling Nord Pool than the old Pool of England and Wales. It allows for self-dispatch instead of giving the National Grid Company the role of scheduler and orderer. It also allows for firms to be paid the price they bid rather than the system marginal price. Further, NETA opens up the wholesale market to nongenerators, thus allowing commodity traders to participate in the market [***14***]. Unlike the old Pool, NETA does not include a capacity mechanism, which is currently the case for the Nord Pool, the California Pool, the Australian National Pool, and the New Zealand Pool [***15***].

The Nord Pool, which has been in operation since 1996, was the world's first international electricity commodity exchange. The Nord Pool evolved from an informal arrangement whereby Scandinavian nations had traded electricity for decades [***16***]. Currently, Denmark, Finland, Norway, and Sweden buy and sell electricity in the Nord Pool. The Nord Pool employs two markets, a day-ahead spot market, Elspot, and a financial market, Eltermin, for weekly contracts. The Eltermin market does not actually trade power. Rather, like the contracts for differences markets which emerged in the United Kingdom and Australia, Eltermin allows for a financial settlement between electricity buyers and sellers. Unlike the pools set up in California and the United Kingdom, the Nord Pool is a voluntary market that is accompanied by a great deal of bilateral trade. In 1998, Elspot and Eltermin accounted for only 20 percent of the total power sold in the Nordic market [***17***].

In 1995, Alberta passed its Electric Utilities Act (EUA), which led to the establishment of an electricity pool in 1996, the Alberta Power Pool, which was a non-profit corporation. Unlike in the United Kingdom, in Alberta electricity buyers and sellers could negotiate direct sales. However, the Alberta Power Pool initially restricted entry into the buy side of the market to entitled buyers, which were the incumbent utilities when the pool was formed [***18***]. In Alberta's pool, prices were not entirely competitive, in that generators were under rate-of-return regulation for their fixed costs. The EUA also established an ISO to manage Alberta's transmission network. In 1998, Alberta adopted amendments to the EUA that were intended to encourage further price competition by allowing independent power production and requiring incumbent utilities to undertake power purchasing arrangements with independent marketers [***19***].

Table 23. Levels of Horizontal Concentration in Selected Generation Markets, 1996 and 1998

Market	Market Share of Two Largest Generators	
	1996	1998
UK (England and Wales)	55	41
Nord Pool	40	35
Australia (National Electricity Market)	40	36
New Zealand	90	53

Source: International Energy Agency, *Competition in Electricity Markets* (Paris, France, February 2001), p. 35.

In setting about electricity reform, California borrowed several elements from the UK model. For example, California's electricity reform required all sales to be conducted through a daily pool [***20***]. In the California Power Exchange, the pool price was set as follows: the California Power Exchange created an electricity supply and demand curve by combining all generator supply bids with all consumer demand bids. The clearing price—the price paid to the generators by the suppliers—was determined by the intersection of the supply and demand curves. This is similar to the pricing scheme initially employed in the United Kingdom, except that in the UK Pool demand was estimated by the National Grid Company. What distinguishes the California exchange from the UK Pool is the separation of the California Independent System Operator (CAISO) from the Power Exchange (PX). Moreover, California reforms did not provide pool participants with the hedging opportunities that the contracts for differences market provided in the United Kingdom and Australia, or the Eltermin market provided Nordic country participants.

Independent System Operators and Regional Transmission Organizations

ISOs have been developed in several states, countries, and provinces. In most cases, the ISO's function is to manage the grid and provide support to regional system operators. There are a number of forms an ISO can take, and there is an ongoing debate as to which is superior. One is a Transco, which is an independent system operator that both owns and operates the grid. Although Transcos may be profit or nonprofit enterprises, they are independent of system sellers and buyers. The National Grid Company in England and Wales is an example of a for-profit Transco [***21***].

In some cases, as mentioned in the above discussion of the UK Pool, the ISO and the pool have been one in the same, as in the case of the National Grid Company, which manages both the grid and the wholesale electricity market. Another form of ISO is the one operating in

California. CAISO is a nonprofit ISO that manages the grid but also allows for a separate power exchange, the California (CAL PX). Ownership of the transmission lines remained with the three major utilities.

Australia, New Zealand, Spain, the United Kingdom, and the Nordic countries have opted for the full separation of the grid from the generation of electricity. In the United Kingdom, Finland, Sweden, and Norway, the grid companies are under separate ownership from generation companies. In California, Spain, and the Netherlands, generators own the grid, but it operates independently from them [***22***]. Argentina created an ISO that was owned by the generation, transmission, and distribution companies [***23***].

Congestion management is a major concern of the newly created ISOs. Congestion management in California was based on a system of zonal pricing, similar to that used in Australia, which differs from the "postage stamp" rates[21] that are insensitive to congestion (and distance) operating in Alberta, Finland, Norway, the United Kingdom, and Sweden [***24***]. In contrast, Argentina, Chile, New Zealand, the PJM, and the New York ISO have opted for zonal pricing systems, which are most sensitive to congestion and distance traveled.

In the United States, current efforts at electricity reform have focused on improving the efficiency of the nation's transmission network. The transmission system in the United States is not a nationwide operation but rather a mixture of balkanized regional arrangements that result in lost trading opportunities and in some cases rates that are artificially higher than they should be. Rates reflect transmission charges that are often "pancaked" when electricity crosses several transmission networks, amassing layer upon layer of tariffs.[22] The overall goal of the new system is the creation of a national grid.

The Federal Energy Regulatory Commission (FERC) recently attempted to promote greater unification of the nation's electricity grid by consolidating the operations of several regional ISOs. The FERC's most recent effort at introducing more competition in the electricity industry was laid out in Order 2000, which was issued December 1999. Order 2000 advocates the formation of RTOs to operate the transmission network. Order 2000 requires that "each public utility that owns, operates, or controls facilities for the transmission of electric energy in interstate commerce" [***25***] be required to submit proposals on how they would participate in RTOs. Order 2000 stated no preference for RTOs to be publicly owned ISOs or privately held Transcos.[23] Order 2000 also took a stance in favor of "zonal pricing"[24] and extensively discussed performance-based ratemaking [***26***].

As a followup to its Order 2000 Rulemaking, on July 12, 2001, the FERC directed the formation of four RTOs in the Northeast, the Southeast, the West, and the Midwest. (Texas would be handled separately.) In the Northeast, it was expected that the PJM pool would merge with ISOs in New England and New York [***27***]. The FERC ordered the groups to use elements of the PJM as a platform for building the new organization. The FERC expects that RTOs representing the Northeast and Southeast will be the first in operation.

The intent behind the creation of RTOs is to improve the coordination of regional transmission activities, which should allow for greater flexibility and efficiency, fewer bottlenecks, and more electricity trade. One benefit of RTOs is that they may lessen the impact of pancaking. It is also hoped that RTOs will reduce discriminatory treatment directed at producers that do not own transmission lines.

Privatization

Naturally, privatization has been a feature of electricity reform only in those nations where electric utilities were publicly owned. Until recently, the United States, Belgium, Germany, and Japan were in general unique among countries in the degree to which privately held companies supplied electric power. For most other countries, electricity asset ownership was public.

Ideological and political factors have in part motivated the different paths undertaken to privatization. In some cases, where privatization was a major component of electricity reform, such as England and Wales, privatization of electricity preceded deregulation. In Australia, efforts to privatize and deregulate have proceeded piecemeal, and in New Zealand, Norway, and Sweden deregulation has occurred largely without privatization [***28***].

A less dramatic step than privatization involves the corporatization of electricity assets. New Zealand, for instance, during its initial electricity reform program

[21]Postage stamp rates refer to the situation where fixed transmission costs are recovered through a single access fee over an entire region.

[22]When multiple regions exist and a generator has to pay separate transmission access fees for moving power through each region, the rates are said to be "pancaked," because they are added on top of one another.

[23]Federal Energy Regulatory Commission, *Regional Transmission Organizations: Final Rule*, Docket No. RM99-2-000, Order 2000, 18 CFR Part 35 (December 20, 1999), p. 6, states: ". . . we do not propose to require or prohibit any one form of organization for RTOs or require or prohibit RTO ownership of transmission facilities. The characteristics and functions could be satisfied by different organization forms, such as ISOs, transcos, combinations of the two, or even new organizational forms not yet discussed in the industry or proposed to the Commission."

[24]Zonal pricing refers to the case where a region is broken into multiple subregions (zones) that have different wholesale electricity prices when transmission congestion occurs between the subregions.

transferred the nation's electricity assets from the Ministry of Energy to a newly created state-owned enterprise, the Electricity Corporation of NZ Ltd. Although the assets were to remain under government ownership, political control was diminished somewhat with the new accounting separation. Similarly, in New South Wales, Norway, Sweden, and Finland, where there has been a strong tradition of public ownership, privatization was not seen as an essential ingredient to achieving more competition in electricity supply. Rather, in general, the industries were reorganized to remove the monopoly franchise and to instill more commercial practices. Norwegian reform, for instance, separated the national grid from the power company.

Regulatory Reform

Several countries have attempted to deregulate the prices of various forms of energy service. Most of the deregulatory effort has focused on generation. For the wires business (transmission and distribution) the adoption of price-cap regulation and movement away from rate-of-return regulation has been a unique feature of recent regulatory reform efforts. The United Kingdom initiated what has become a much imitated model, allowing generation companies to sell their goods into a competitive market at competitive prices but applying a novel form of incentive regulation for the transmission and distribution sides of the business. Price-cap regulation attempts to restrain costs by applying price ceilings. Price-cap regulation was used as a means of instilling efficiency gains in the UK wire business. The price cap, known in the United Kingdom as RPI-X, allows for inflation-adjusted prices less expected efficiency gains. This form of "performance-based" regulation has been duplicated in other nations, including Argentina, Australia, New Zealand, and, in the United States, California and Texas.

Texas imposed a similar form of incentive regulation in its "price to beat." The "price to beat" is a price established to stimulate competition for sales to residential and small commercial customers. It is scheduled to go into effect in Texas in January 2002. For existing electric utilities the "price to beat" was set at 6 percent below the regulated retail rates in effect on January 1, 1999.

Open Access

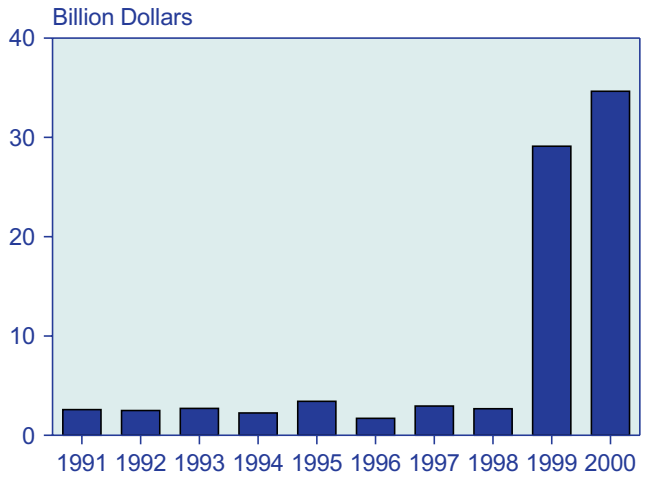
Nondiscriminatory open access to the electricity grid has been a major goal of electricity reform in Australasia, North America, Western Europe, and South America. New Zealand's transmission system has been open to all levels of demand since reform efforts got started in 1994. Norway introduced open access when it began its reforms in 1991. Western Europe is currently the scene of attempts to create a continent-wide electricity market. A 1996 European Community directive required all signatories to open up their electricity markets to new suppliers starting in February 1999.

Since opening their markets to non-incumbent suppliers, some countries have seen more or less switching among large customers. In some cases, switching has been deterred when incumbent suppliers have reduced prices in order to forestall market entry by new suppliers.

Foreign Investment

Although the desire to attract foreign investment has been an important motivation for electricity reform in the developing world, it has been the developed nations that have seen the greatest flows of foreign investment into their electricity sectors. For example, between the middle of 1995 and early 1997, U.S. utilities acquired 8 of the 12 privatized regional electricity companies in the United Kingdom, in transactions valued at more than $25 billion in total. Similarly, in Australia, many electricity assets were purchased by U.S.- and UK-based companies after Australia deregulated its electricity sector and opened it up to foreign investors. In turn, several companies from the United Kingdom have recently acquired U.S. electricity assets, a development heretofore rare in the U.S. electricity industry. The largest was Scottish Power's purchase of PacifiCorp of Oregon in 1999, valued at an estimated $12.9 billion. Indeed, the value of foreign investment in U.S. utilities rose from $2.8 billion in 1998 to $34.6 billion in 2000 (Figure 78),

Figure 78. Foreign Direct Investment in U.S. Utilities, 1991-2000



Note: The utility investments shown include, in addition to electricity, natural gas distribution and sanitary services; however, the sharp rise in investments during 1999 is largely the result of investments in U.S. electric utilities by foreign companies.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (various issues).

exceeding the value of U.S. investment in overseas utilities (Figure 79).

Developing nations have also attracted some foreign investment. In some instances, particularly in Asian nations, foreign capital has been restricted to greenfield electricity generation projects. In contrast, in South America, foreign investors have been allowed to acquire domestic utilities in their entirety.

Retail Competition

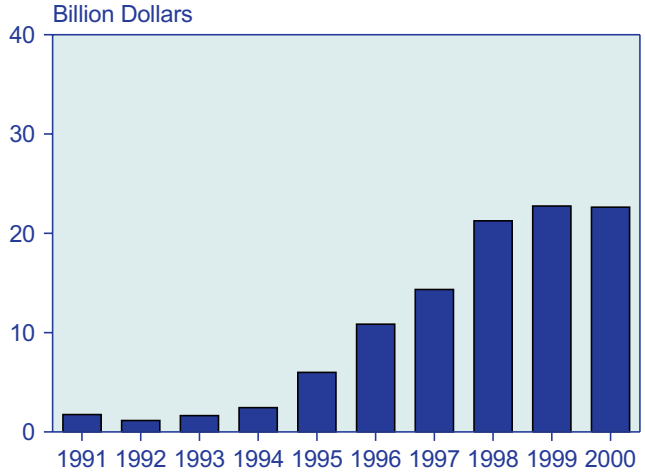
One of the most far-reaching of all electricity reform efforts has been to allow consumers to choose their electricity suppliers, which could in some ways be seen as the other side of open access. In general, retail choice has been offered first at the wholesale level to large, primarily industrial and commercial users of electricity. Offering the ability to choose one's supplier to households has not been as widespread, and in at least one instance (California) has been less successful than efforts to open up wholesale markets. One of the difficulties faced by new suppliers trying to encourage households to switch from their incumbent suppliers is that any savings that a new supplier might provide as a result of better management of its generation or wires business is likely to be only a small percentage of the average household electricity bill, which is heavily weighted toward such costs as service fees, hookup charges, and billing fees.

Some countries and states have, by and large, had good experiences with retail competition. Norway, New Zealand, Finland, Germany, Australia, the United Kingdom, and Pennsylvania have generally been successful in introducing competition at the household level. It has been suggested that by 2007 an estimated 500 million OECD consumers will be able to choose their electricity suppliers [***29***]. In the United States, roughly half of the States have adopted plans for retail competition, and retail competition is currently available in Massachusetts and Rhode Island. In Texas retail choice began in 2002 [***30***]. In Australia, the state of Victoria has offered retail choice since January 2001, and New South Wales is expected to offer retail choice by January 2002 and South Australia by January 2003.

Retail choice has in some instances led to greater competition in electricity markets. Between October 1999 and February 2000, 7 percent of Scandinavian households switched electricity providers, and another 18 percent renegotiated electricity prices with incumbent suppliers [***31***]. By February 2000, 14 percent of consumers in England and Wales had switched suppliers [***32***]. In Germany, by the year 2005, "71 percent of industrial users, 45 percent of commercial users and 32 percent of residential users are expected to switch providers" [***33***].

California's experience with retail choice was less successful. In California, Assembly Bill 1890 provided customer choice by allowing more than 70 percent of California's electricity customers to change providers. By the time the retail market was opened to competition, 250 power marketing companies had signed up to sell electricity directly to California consumers. California consumers have, however, been reluctant to switch from their incumbent suppliers. They may have been discouraged by retail rate caps and by the fees charged for making a switch.

Figure 79. U.S. Direct Investment in Overseas Utilities, 1991-2000



Note: The utility investments shown include, in addition to electricity, natural gas distribution and sanitary services; however, the sharp rise in investments from 1995 through 1999 is almost entirely the result of investments in overseas electric utilities by U.S. companies.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (various issues).

References

1. A.K. Izagure, "Private Participation in the Electricity Sector—Recent Trends," Public Policy for the Private Sector, Note No. 154 (Washington, DC: World Bank, September 1998).
2. International Finance Corporation, *Project Finance in Developing Countries* (Washington, DC: World Bank, May 1999).
3. International Finance Corporation, *Project Finance in Developing Countries* (Washington, DC: World Bank, May 1999).
4. K.G. Jechoutek and R. Lamech, "Private Power Financing—From Project Finance to Corporate Finance," Public Policy for the Private Sector, Note. No. 56 (Washington, DC: World Bank, October 1995).
5. J.E. Besant-Jones and B. Tenenbaum, "Lessons from California's Power Crisis," *Finance and Development*, Vol. 38, No. 3 (September 2001).

6. International Energy Agency, *Energy Prices & Taxes: Quarterly Statistics* (Paris, France, Third Quarter 2001).
7. Energy Information Administration, "U.S. Electric Utility Average Revenue per Kilowatthour (Retail Price) Data: Historical: Average Annual Revenue for All Sectors by State," web site www.eia.doe.gov.
8. Organization for Economic Cooperation and Development, *OECD Economic Outlook*, No. 67 (September 2001), p. 162.
9. International Energy Agency, *Competition in Electricity Markets* (Paris France, February 2001), p. 83.
10. A. Huber, D.T. O'Leary, and J. Charpentier, "New Paradigms for Information Processing in National and Regional Electricity Markets," Infrastructure, Business Briefing, World Market Research Center, web site www.wmrc.com/businessbriefing/pdf/infrastructure2001/tech/Siemens.pdf.
11. F. Woolf, "The Unbundling and Rebundling of Transmission and Market Related Functions," *Electricity Journal*, Vol. 9, No. 10 (December 1996), pp. 44-51.
12. National Economic Research Associates (NERA), *Transmission Pricing: International Developments* (Sydney, Australia, May 1998).
13. Energy Information Administration, *Electricity Reform Abroad and U.S. Investment*, DOE/EIA-0616 (Washington, DC, October 1997).
14. J. Chennells, "Electricity Trading the NETA Way," *World Power 2001*, pp. 166-167.
15. International Energy Agency, *Competition in Electricity Markets* (Paris France, February 2001), p. 83.
16. L. Carlsson, "The International Power Trade—The Nordic Power Pool," Public Policy for the Private Sector, Note No. 171 (Washington, DC: World Bank, January 1999).
17. P. Myrseth, "The Nordic Power Market and Its Use of Electronic Commerce," NORSK Regnesentral, web site www.nr.no/~pmyrseth/foredrag/oecd_ie_workshop_99/ (June 16, 1999).
18. Power Pool of Alberta, "General Information: History," web site www.powerpool.ab.ca.
19. D. Burtraw, K. Palmer, and M. Heintzelman, "Electricity Restructuring: Consequences and Opportunities for the Environment," Discussion Paper 00-39 (Washington, DC: Resources for the Future, September 2000), p. 66.
20. International Energy Agency, *Competition in Electricity Markets* (Paris France, February 2001), p. 89.
21. W.W. Hogan, "Regional Transmission Organizations: Millennium Order on Designing Market Institutions for Electronic Network Systems," web site www.ksg.harvard.edu/hepg/ (May 2000).
22. G. Shuttleworth, *Opening European Electricity and Gas Markets* (Washington, DC: National Economic Research Associates, November 2000), p. 16.
23. R.P. Lalor and H. Garcia, "Reshaping Power Markets—Lessons from Chile and Argentina," Public Policy for the Private Sector, Note No. 85 (Washington, DC: World Bank, June 1996).
24. International Energy Agency, *Competition in Electricity Markets* (Paris France, February 2001), p. 35.
25. Federal Energy Regulatory Commission, *Regional Transmission Organizations: Final Rule*, Docket No. RM99-2-000, Order 2000, 18 CFR Part 35 (December 20, 1999), p. 1.
26. Federal Energy Regulatory Commission, *Regional Transmission Organizations: Final Rule*, Docket No. RM99-2-000, Order 2000, 18 CFR Part 35 (December 20, 1999), pp. 157 and 397.
27. "FERC Maps New Vision of Grid—One with Four Major RTOs," *Electrical World*, Vol. 215 (July/August 2001), p. 6.
28. International Energy Agency, *Competition in Electricity Markets* (Paris France, February 2001), p. 33.
29. International Energy Agency, "Electricity Market Reform: California and Afterward," web site www.iea.org/about/emr.pdf (March 2001).
30. Energy Information Administration, *The Changing Structure of the Electric Power Industry 2000: An Update*, DOE/EIA-0562(2000) (Washington, DC, March 2000), p. 85.
31. "Retail Markets Over There: Has Supply Competition Taken Root?" Harvard Electricity Policy Group, Twenty-Second Plenary Session, Rapporteur's Summary, Session Two (Cambridge, MA, May 22-23, 2000), web site www.ksg.harvard.edu/hepg/.
32. L. Kiesling, *Getting Electricity Deregulation Right: How Other States and Nations have Avoided California's Mistakes*, Policy Study No. 281 (Los Angeles, CA: Reason Public Policy Institute, April 2001), p. 12.
33. L. Kiesling, *Getting Electricity Deregulation Right: How Other States and Nations have Avoided California's Mistakes*, Policy Study No. 281 (Los Angeles, CA: Reason Public Policy Institute, April 2001), p. 13.